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Educational Conditions for Successful Training with Virtual Reality Technologies

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Summary

The paper focuses on those pedagogical conditions, which should be met, in order to assure successful training using virtual reality (VR) technologies. Therefore, neither new technical inventions nor large scale technical experiments are the issue of this paper. Instead a systematic catalogue of pedagogical questions will be proposed, which should be answered, before virtual reality is planned for training purposes.

The pedagogical catalogue is derived from the basics of educational psychology and media didactics. It comprises
- a taxonomy of learning objects, which are most suitable for virtual reality
- an analysis of training strategies and methods, as to how well they are suited for training in an almost entirely synthetic environment
- an analysis of the transfer of training, when virtual reality is the major training medium
- and finally rules and basic cost data, which may help to conduct cost effectiveness analyses.

Introduction

In this paper I will try to give a short and comprehensive overview on the basics of educational theory, which should be applied to training with VR technologies. I will do this in five statements. Each statement or thesis is accompanied by explanations. I start with a new look on a well known definition.

Probably everyone in this conference knows, what VR is. Nevertheless, I will give my own add-on to a commonly used definition and comment this definition. I do this, because I want to define important educational issues.

The common definition reads as follows:

VR is "a multi-dimensional human experience which is totally or partially computer generated and can be accepted by those experiencing the environment as consistent" (NATO DRG Panel 8 on Human Sciences, RSG 16).

My add-on is:

VR is a capability beyond life, virtual and constructive simulation and of course much beyond Computer Based Training systems, however it can be coupled with CBT. VR can be created, in order to convey training objectives and support training strategies.

Basic Statements

1. Statement

If training is the aim of VR, VR training programmes must comply with the basics of social and educational psychology.

These basics do not differ from what should generally be valid about training with constructive and virtual simulation. VR is an other example that there should be such things as simulation didactics. VR, however, increases the pedagogical requirements to be considered. These requirements concern mainly
- the distribution of learning material in a multi-sensory (multi-channel) experience (e.g. seeing, hearing, feeling of one's own body, feeling of material properties, stress, decision making)
- the real experienced presence of an instructor and of other students during the learning and exercising process (social learning)
- the merging into VR and leaving the virtual environment (e.g. different feeling of own security).

Related to these three general problems are the following practical questions, which will partially be answered in this paper:
- Are VR technologies justified by relevant *training objectives*?
- Do VR training programmes enhance the quality of instruction and bring about better *training strategies*?
- Can the typical military *crew and leadership behaviour* be preserved in VR, where this is necessary for training?
- Are the offerings of VR *accepted* by experts of training and operation as an environment that facilitates learning?
- Will there be a chance to construct a *consistent* training scenario with new synthetic elements of the human environment?

These are the educational questions, which the VR community is invited to discuss further.

2. Statement

If we take the classical taxonomy of learning objectives, VR can be a relevant medium in complex psycho-motor training, only for certain cognitive tasks, may be to indoctrinate in the emotional and affective domain and (as a still controversial matter) in a real social context.

In principal VR is useful for the following four types of non-trivial application:

- Perceptual-motor learning, where real images are mixed with virtual components, e.g. the real hand manipulating computer generated interfaces (this is also called Augmented Reality),
- Perceptual cognitive training, when it becomes necessary to build a "mental map" on the basis of experience from various sense channels, not only based on the visual system, e.g. complex assembly tasks involving orientation in space, finding objects and moving them from one place to an other, discriminating different objects
- In general for team training in large scale exercises like C² training, large staff exercises, disaster control, but only as far as co-ordination skills and procedures are concerned
- And finally the exploration of unknown environments, provided that the data are up to date.

Examples for these types of application are
- Mission rehearsal, where all merits of VR are combined
- Reconnaissance, where VR however must have an added value to conventional simulation and training.

The total immersion into a synthetic environment leads to the exclusion of non-intended and disturbing information. This fact can be used or better: misused for indoctrination purposes. Sales promotions, radical behaviour changes, rapid conveying of emotional stimulus response patterns can be the objectives of such techniques. This again leads to the question, if and how much VR inhibits the ability of critical distance to the learning of those tasks, which require a critical attitude, e.g. all tasks comprising decision making between not fully transparent alternatives.

The impact of total immersive VR technology on the emotional behaviour is therefore a challenging new research question.

Social learning is however not yet sufficiently researched in fully immersive VR. The main problem lies in the isolating effect of VR. This means that it is still a not yet proven hypothesis, whether the acquisition of interpersonal skills, even and especially if they are interconnected with cognitive or procedural tasks can be supported by those VR technologies, which isolate the individual from direct personal contact with another individual in the same learning group. There are, however, semi-immersive VR-technologies like the cave- technique or the virtual workbenches, where individuals interact with each other "naturally". These techniques cover therefore in principle the all classes of learning objectives.

3. Statement
Training Strategies in VR do not differ much from those in virtual simulation and in CBT. However, they require more dedicated analysis and development, because VR offers more perceptual cues.

In comparison to constructive and virtual simulation VR has some distinctive features, which make it particularly valuable for articulated teaching and learning strategies. These features are:
- a broader perceptual spectrum
- a higher degree of differentiation in the perceptions (e.g. more depth cues)
- a higher degree of interactivity with the virtual environment.

These three properties of a deeper immersion into the artificial world offer the possibility, to differentiate and structure learning activities in a more effective way.

The advantages of learning and teaching with VR technologies are:
- *more learning material can be presented to the students*
- part task and part function training can be applied to a broader variety of learning tasks
- feedback control of learning success can become more differentiated and apply to a broader spectrum of tasks
- it may become easier to compose a set of part tasks to a real world like whole task in a almost realistically perceived learning environment.

However, VR requires a much more developed art of constructing the curricula and of designing the learning programmes and the learning aids. In short: VR makes the training development much more demanding and requires higher developmental qualifications.

4. Statement
The transfer of training into the operational situation has to be carefully analysed, because VR represents nevertheless only a part of "real reality".

As we have already said, the social dimension of reality is still hardly present in learning with VR technologies. Along with this, decisive other aspects of the learner are still drastically altered. These are
- the perception of the bodily self, which may be necessary in many psycho-motor learning tasks
- the unnatural feeling of wearing a helmet or a glove, which does either not resemble the normally worn helmets and gloves, or is a totally unrealistic feeling
- the multi-sensory perception of the environment. e.g. the not real feeling to walk a distance
- the apperception of the partner in the learning process, whenever this may be required for the acquisition of team building skills
- the apperception of the instructors, whenever this may have a motivational effect on the learning process or is a part of team building skills — remember that in typical military tasks training and personal example and leadership can not be separated.

All this means that skill acquisition by means of VR technologies puts the learner in sometimes extremely artificial surroundings, encapsulates his consciousness and lets him leave this virtual world with a repository of artificial behaviours. The first thing after leaving the artificial world of VR is to re-learn those behaviours, which do not fully comply with the operational

environment, to de-condition the learner away from the partially reduced and partially enriched experience towards a normal interaction with the operational environment. This again means, that although VR is an expensive training and an often time valuable medium, the transfer of training cannot be taken for granted and must be ascertained with much effort. If the curricular and didactic analysis has identified those tasks and skills that cannot be trained with VR, the transfer of training of the remaining VR-prone tasks can be evaluated without too big problems.

5. Statement
Cost and effectiveness of training with VR must be compared with training using virtual simulation. Whenever virtual simulation is feasible, VR should be analysed, whether it can produce better or cheaper solutions than virtual simulation.

On the effectiveness side of the comparison cost effectiveness analyses should consider the following issues:

- The enhanced representation of new and extended sensorial perceptions may *increase* the effectiveness.
- The possibility of mission rehearsal and procedural training in extreme situations, where total immersion is the only realistic experience, may also *increase* the effectiveness (good example may be the training for operations and maintenance in space or deep water).
- The reduced personal and interpersonal experience is definitely a factor, which *decreases* the effectiveness of VR in training.

On the cost side of the comparison the following issues should be considered:

- The HMD technology is a cost *decreasing* factor.
- The software development is a drastically increasing factor.
- Re-training and special transfer of training analyses can become cost *increasing* factors.

Therefore, considering VR for training should always start with cost effectiveness analyses based upon thoroughly conducted training analyses. However, the cost savings can reach several orders of magnitude, if training using VR is correctly designed. Examples are cargo handling skills or air drop skills, where the real aeroplane would be too expensive and virtual simulation is not giving the necessary depth cues.

Conclusion
To conclude this survey: What are the conditions of success of VR in training?

1. For the time being a limitation to tasks, which do not imply any personal proximity of other persons.
2. For the future more critical research into the interpersonal and social impact of VR and how far social interactions can be simulated in an total immersive environment.
3. Always limitation to empirically researched and proven simulation cues.
4. Always embedded in a well controlled transfer of training evaluation.
5. Always planned on the basis of cost effectiveness analyses.

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